

What Is Claimed Is:

1. A composite structure, comprising:

two molded outer polymeric layers spaced apart from each other and defining a cavity therebetween, wherein each molded outer polymeric layer defines a sealing surface extending about a periphery of the respective layer, and the opposing sealing surfaces cooperate to define a hermetic seal extending about a periphery of the cavity;

at least two multi-directional fiber reinforcement layers, each multi-directional fiber reinforcement layer being mounted adjacent to a respective outer polymeric layer and defining a first region of the cavity extending between each respective outer polymeric layer and adjacent fiber reinforcement layer, and a second region of the cavity extending between the fiber reinforcement layers; and

a core located between the two outer polymeric layers and made of a core material capable of exhibiting a foamed character and a resinous character;

wherein the core material includes a resin and a blowing agent activatable upon exposure to a predetermined vacuum pressure within the cavity to convert the core material within the second region of the cavity from a resinous character to a foamed character; and

wherein the second region of the cavity is substantially filled with the core material exhibiting the foamed character, each multi-directional fiber reinforcement layer is impregnated with the core material exhibiting a relatively dense, resinous character, and each first region of the cavity is substantially filled with the core material exhibiting a resinous character and fixedly securing the multi-directional fiber reinforcement layers to the outer polymeric layers.

2. A composite structure as defined in claim 1, wherein the resin of the core material is a polyurethane foam.

3. A composite structure as defined in claim 1, wherein the core material comprises a polyisocyanurate foam.

4. A composite structure as defined in claim 3, wherein the core material exhibits an isocyanate index within the range of approximately 130 to approximately 400.

5. A composite structure as defined in claim 4, wherein the core material exhibits an isocyanate index within the range of approximately 150 to approximately 250.

6. A composite structure as defined in claim 1, wherein the blowing agent exhibits a boiling point below approximately 50° C.

7. A composite structure as defined in claim 1, wherein each multi-directional fiber reinforcement layer defines a predetermined permeability which (i) allows the resinous core material to impregnate the respective fiber layer, (ii) substantially prevents the core material located within the respective fiber layer from converting to its foamed character within said fiber layer, and (iii) substantially prevents the core material in its foamed character from penetrating the respective fiber layer.

8. A composite structure as defined in claim 7, wherein each multi-directional fiber reinforcement layer includes a plurality of approximately parallel fibrous tow bundles, and a predetermined stitching connecting together the tow bundles and allowing each bundle to move laterally a distance within the range of approximately 1 through approximately 2 times a width of the respective bundle.

9. A composite structure as defined in claim 1, wherein the blowing agent is activatable upon exposure to a predetermined vacuum pressure within the range of approximately 10 inches Hg through approximately 29 inches Hg.

10. A composite structure as defined in claim 1, wherein the outer polymeric layers are each made of a material selected from the group including thermoplastic and thermoset materials.

11. A composite structure as defined in claim 8, wherein each tow bundle defines interstices between the fibers of the bundle, and the interstices of the bundles are impregnated with the resinous core material.

12. A composite structure as defined in claim 1, wherein the at least two multi-directional fiber reinforcement layers include at least one directional fiber ply, and at least one random fiber ply located between the directional fiber ply and respective outer polymeric layer, and wherein both the directional fiber ply and random fiber ply are impregnated with the

5 resinous core material, and the relatively dense, resinous layer is formed between the random ply and respective outer polymeric layer.

13. A composite structure as defined in claim 1, wherein the resinous core material located within the at least one layer of fibrous material and at least one first region defines a void content of less than approximately 35%.

5 14. A composite structure as defined in claim 1, further comprising a plurality of beads of adhesive applied to a surface of each outer polymeric layer facing a respective fiber-reinforcement layer and adhesively attaching the fiber-reinforcement layer thereto, wherein the beads of adhesive are applied to each outer polymeric layer in a discontinuous manner such that the adhesive beads are disposed amongst relatively large areas of the surface of the respective outer polymeric layer that are free of adhesive, and the surface areas that are free of adhesive are substantially filled with the core material exhibiting the resinous character and fixedly securing the adjacent fiber-reinforcement layer to the respective outer polymeric layer.

15. A composite structure as defined in claim 14, wherein the adhesive is a pressure sensitive adhesive.

16. A composite structure as defined in claim 14, wherein the adhesive is a radiation activatable adhesive for curing the adhesive by subjecting the adhesive to radiation to thereby secure the fiber-reinforcement layers to the outer polymeric layers.

17. A composite structure as defined in claim 14, wherein the adhesive beads cover approximately 5% through approximately 15% of the area of each respective outer polymeric layer surface.

18. A composite structure as defined in claim 14, wherein the adhesive beads engage and wick into the respective fiber-reinforcement layer.

19. A composite structure as defined in claim 1, wherein at least one outer polymeric layer defines a gate formed in a peripheral region thereof and connectable in fluid communication with the cavity for introducing the core material in the resinous character through the gate and into the cavity, and the opposing sealing surfaces extend adjacent to a periphery of the gate and cooperate to seal the gate.

20. A composite structure as defined in claim 19, wherein the gate defines a predetermined shape that allows the resinous core material to transition from a turbulent flow to a substantially laminar flow upon exiting the gate and entering the cavity.

21. A composite structure as defined in claim 1, wherein the sealing surface of at least one outer polymeric layer defines a relatively raised, elongated rib, and the rib is deformable upon the application of pressure thereto to form the hermetic seal extending about the periphery of the cavity.

22. A composite structure as defined in claim 1, further comprising at least one structural insert spaced a predetermined distance from a respective outer polymeric layer and defining a third region of the cavity extending between the respective outer polymeric layer and structural insert, and wherein the resinous core material substantially fills the third region to thereby
5 fixedly secure the structural insert within the composite structure.

23. A composite structure as defined in claim 22, further comprising at least one fibrous layer located on an opposite side of the structural insert relative to the respective outer polymeric layer, and impregnated with resinous core material fixedly securing the fibrous layer to the structural insert.

24. A composite structure as defined in claim 22, further comprising at least one spacer located between the structural insert and respective outer polymeric layer and setting the predetermined distance between the structural insert and outer polymeric layer.

25. A composite structure as defined in claim 24, wherein the at least one spacer defines a first aperture therethrough, the respective outer polymeric layer defines a second aperture therethrough, and the first and second apertures are substantially aligned to thereby permit the attachment of fasteners or other devices within the apertures.

26. A composite structure as defined in claim 25, wherein the spacer defines a threaded aperture for receiving therein threaded members.

27. A composite structure as defined in claim 24, wherein the spacer is formed by a surface of the respective outer polymeric layer.

28. A composite structure as defined in claim 1, wherein the at least one outer polymeric layer is in the form of a multi-layer extrusion including (i) a first layer defining a cosmetic surface, (ii) a second layer defining a core, and (iii) a third layer defining a relatively chemical-resistant surface.

29. A composite structure as defined in claim 1, wherein at least one of the multi-directional fiber reinforcement layers defines a plurality of approximately parallel fibrous tow bundles, the composite structure defines at least one dimension selected to exhibit relatively reduced differential thermal expansion in comparison to other dimensions of the composite structure, and the tow bundles of said fibrous layer are aligned with an axis of the selected dimension to thereby reduce the differential thermal expansion of the composite structure in the direction of said axis.

30. A composite structure as defined in claim 29, wherein the tow bundles are aligned with the largest dimension of the composite structure.

31. A composite structure as defined in claim 1, wherein at least one of the outer polymeric layers defines at least one vacuum port formed through a peripheral portion thereof and connectable in fluid communication with the cavity for evacuating the cavity prior to introducing the core material therein.

32. A composite structure as defined in claim 31, further comprising at least one filter slidably received within the at least one vacuum port for allowing the passage of gas through the at least one port and substantially preventing the passage of resinous core material therethrough.

33. A composite structure as defined in claim 31, wherein said at least one polymeric layer further defines at least one vacuum conduit coupled in fluid communication between the at least one vacuum port and the cavity and extending about the periphery of the cavity for connecting the cavity in fluid communication with the at least one vacuum port.

34. A composite structure as defined in claim 28, wherein the second layer of the at least one outer polymeric layer defines relatively increased thermal stability, impact resistance, and modulus stiffness in comparison to the first and second layers thereof.

35. A composite structure as defined in claim 28, wherein the third layer of the at least one outer polymeric layer is chemically compatible with the core material and defines a tie layer between the core and the respective outer polymeric layer.

36. A composite structure as defined in claim 35, wherein the third layer defines a plurality of receptor sites for bonding thereto the core material.

37. A composite structure as defined in claim 28, wherein the first layer of the at least one outer polymeric layer defines an automotive class A surface finish.

38. A composite structure as defined in claim 28, wherein the first layer of the at least one outer polymeric layer defines an automotive class A ready for paint surface.

39. A composite structure as defined in claim 1, wherein each molded outer polymeric layer is thermoformed into a predetermined shape.

40. A composite structure as defined in claim 1, further comprising a finished edge extending about a periphery of the composite structure and defining an exposed surface formed by a first one of the polymeric layers, and a trim line spaced laterally inwardly relative to the finished edge and along which the composite structure is trimmed to form a finished part.

41. A composite structure as defined in claim 40, wherein the finished edge defines a first edge surface extending laterally outwardly from the composite structure along the periphery thereof, and a second edge surface extending laterally inwardly relative to the first edge surface and between the first edge surface and the trim line.

42. A composite structure as defined in claim 41, wherein at least one of the first and second edge surfaces is curvilinear.

43. A composite structure as defined in claim 1, wherein each of the first and second molded outer polymeric layers defines a peripheral portion extending about the periphery of the

respective layer, and a trim line spaced laterally inwardly from the peripheral portion and along which the composite structure is trimmed to form a finished part.

44. A composite structure, comprising:

two molded outer polymeric layers spaced apart from each other and defining a cavity therebetween, wherein each molded outer polymeric layer defines a sealing surface extending about a periphery of the respective layer, and the opposing sealing surfaces cooperate to hermetically seal the cavity;

at least two fiber reinforcement layers, each fiber reinforcement layer being mounted adjacent to a respective outer polymeric layer and defining a first region of the cavity extending between each respective outer polymeric layer and adjacent fiber reinforcement layer, and a second region of the cavity extending between the fiber reinforcement layers;

a core located between the two outer polymeric layers and made of a core material capable of exhibiting a foamed character and a resinous character;

wherein the core material includes a resin, a blowing agent activatable upon exposure to a predetermined vacuum pressure within the cavity to convert the core material within the second region of the cavity from a resinous character to a foamed character, and a catalyst capable of initiating a catalytic reaction in the foamed core material;

the second region of the cavity is substantially filled with the core material exhibiting the foamed character by evacuating the cavity to approximately a predetermined vacuum pressure therein, activating the blowing agent by subjecting the core material to the vacuum pressure within the cavity and, in turn, converting the core material in the second region of the cavity from a resinous character to a foamed character; and

each fiber reinforcement layer is impregnated with the core material exhibiting a relatively dense, resinous character, and each first region of the cavity is substantially filled with the core material exhibiting a resinous character to fixedly secure the fiber reinforcement layers to the outer polymeric layers by converting the foamed core material that contacts each fiber reinforcement layer into a resinous character, and creating a relatively dense, resinous interface between the fiber reinforcement layer and the foamed core material, and initiating a catalytic reaction within the core material and creating a negative pressure gradient in the direction from the foamed core toward the respective fiber reinforcement layer to thereby impregnate the fiber reinforcement layer and substantially fill the respective first region of the cavity with the resinous core material.

45. A composite structure as defined in claim 44, wherein each fiber reinforcement layer is a multi-directional fiber reinforcement layer.

46. A composite structure as defined in claim 44, wherein the core material comprises a polyol mixture and isocyanate.

47. A composite structure as defined in claim 44, wherein the at least two multi-directional fiber reinforcement layers include at least one directional fiber mat, and at least one random fiber mat located between the directional fiber mat and respective outer polymeric layer, and wherein both the directional fiber mat and random fiber mat are impregnated with the resinous core material, and the relatively dense, resinous layer is formed between the random mat and respective outer polymeric layer.

48. A composite structure as defined in claim 44, further comprising a plurality of beads of adhesive applied to a surface of each outer polymeric layer facing a respective fiber-reinforcement layer and adhesively attaching the fiber-reinforcement layer thereto, wherein the beads of adhesive are applied to each outer polymeric layer in a discontinuous manner such that the adhesive beads are disposed amongst relatively large areas of the surface of the respective outer polymeric layer that are free of adhesive, and the surface areas that are free of adhesive are substantially filled with the core material exhibiting the resinous character and fixedly securing the adjacent fiber-reinforcement layer to the respective outer polymeric layer.

49. A composite structure as defined in claim 44, wherein at least one outer polymeric layer defines a gate formed in a peripheral region thereof and connectable in fluid communication with the cavity for introducing the core material in the resinous character through the gate and into the cavity, and the opposing sealing surfaces extend adjacent to a periphery of the gate and cooperate to seal the gate.

50. A composite structure as defined in claim 49, wherein the gate defines a predetermined shape that allows the resinous core material to transition from a turbulent flow to a substantially laminar flow upon exiting the gate and entering the cavity.

51. A composite structure as defined in claim 44, wherein the sealing surface of at least one outer polymeric layer defines a relatively raised, elongated surfaced portion, and the elongated surface portion is deformable upon the application of pressure thereto to form the hermetic seal extending about the periphery of the cavity.

52. A composite structure as defined in claim 44, further comprising at least one structural member spaced a predetermined distance from a respective outer polymeric layer and defining a third region of the cavity extending between the respective outer polymeric layer and structural member, and wherein the resinous core material substantially fills the third region to thereby fixedly secure the structural member within the composite structure.

53. A composite structure as defined in claim 44, wherein at least one of the outer polymeric layers is in the form of a multi-layer extrusion including (i) a first layer defining a cosmetic surface, (ii) a second layer defining a core, and (iii) a third layer defining a relatively chemical-resistant surface.

54. A composite structure as defined in claim 1, wherein at least one of the outer polymeric layers defines at least one vacuum port formed through a peripheral portion thereof and connectable in fluid communication with the cavity for evacuating the cavity prior to introducing the core material therein.

55. A composite structure as defined in claim 54, further comprising at least one filter slidably received within the at least one vacuum port for allowing the passage of gas through the at least one port and substantially preventing the passage of resinous core material therethrough.

56. A composite structure as defined in claim 54, wherein said at least one polymeric layer further defines at least one vacuum conduit coupled in fluid communication between the at

least one vacuum port and the cavity and extending about the periphery of the cavity for connecting the cavity in fluid communication with the at least one vacuum port.

57. A composite structure as defined in claim 44, further comprising a finished edge extending about a periphery of the composite structure and defining an exposed surface formed by a first one of the polymeric layers, and a trim line spaced laterally inwardly relative to the finished edge and along which the composite structure is trimmed to form a finished part.